Combining Field Proximal and Space-borne Reflectance Time Series for Evaluation of Canopy Function and Productivity

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BACKGROUND AND METHODS

High spectral resolution images provide an efficient tool for evaluation of the ability of vegetation to sequester carbon due to changes in vegetation chemical and structural composition. The goals of this study are to better understand how the fine temporal scale high spectral resolution VNIR measurements and vegetation indices (VIs) relate to canopy photosynthetic function and gross primary productivity (GPP), and thus contribute to improve the current approaches for monitoring the dynamics in vegetation function.

This study presents findings from preliminary analysis of field Fluorescence Box (FLoX, JB Hyperspectral), a tower-mounted automated system collecting a time series of very-high spectral resolution measurements, and space-borne DLR Earth Sensing Imaging Spectrometer (DESIS) reflectance time series covering the visible near-infrared regions (VNIR). Data were collected at a different temporal, spectral and spatial resolutions at the Smithsonian Environmental Research Center (SERC) deciduous forest eddy covariance site in Edgewater, MD, USA. The FLoX system collects upwelling and down-welling measurements every couple of minutes, which were processed to reflectance and solar induced fluorescence using open-source R packages and FLoX Processing GUI 30.3 (JB-Hyperspectral). Mid-day proximal field and space borne reflectance measurements corresponding by acquisition date and time were assembled and the differences in reflectance properties and canopy traits (e.g., chlorophyll, carotenoids, dry matter, and water content) were evaluated for the flux tower footprint.

We used the Soil Canopy Observation Photosynthesis Energy (SCOPE) biophysical model in an inversion to estimate canopy traits and in a forward simulation to derive gross primary productivity (GPP). Comparing the proximal and space-borne estimates of vegetation traits provides a step for upscaling from field to satellite level of canopy reflectance and vegetation functional traits.

STUDY SITE, DATA COLLECTION and PROCESSING WORKFLOW

SERC/NEON Tower Footprint and FLoX Field of View (FOV)

Data Collections and Processing

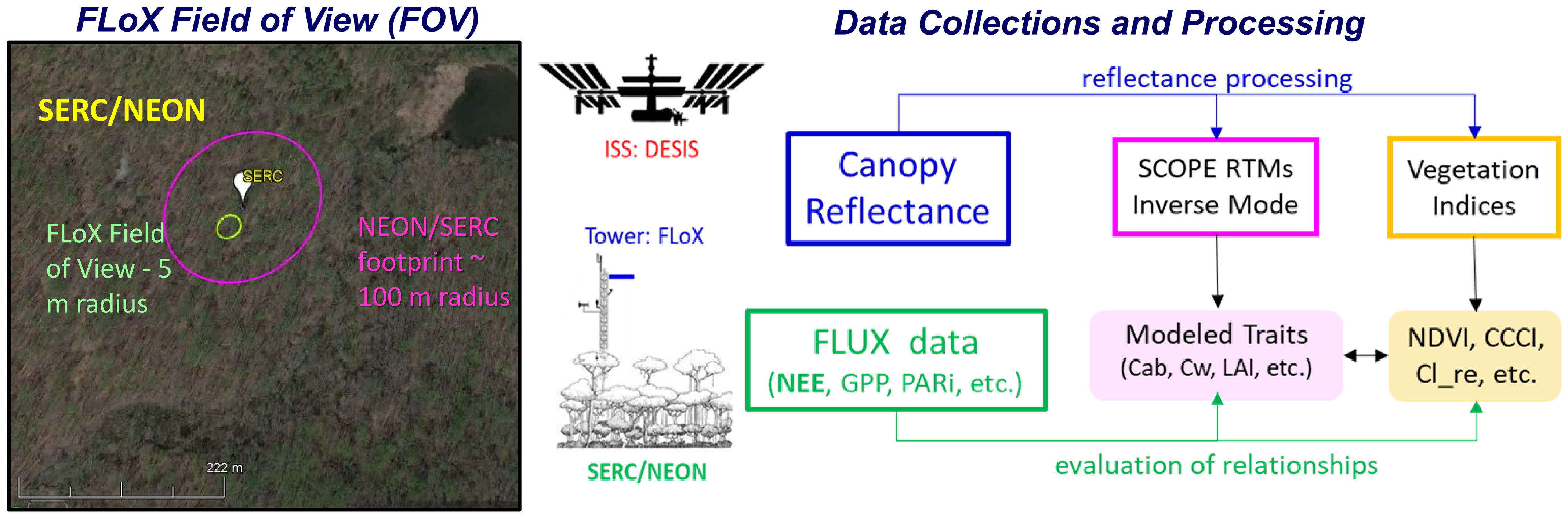

Table 1. *Vegetation Indices (VIs) and Their Calculation*

Index	Name	Formula
NDVI	Normalized diference VI	(R850 - R685)/(R850 + R685)
CI-RE	Chlorophyll index red-edge	R850/R715 - 1
PRI	Photochemical reflectance index	(R531 - R570)/(R531 + R570)
CCCI	Canopy chlorophyll content index	((R850 - R715)/(R850 + R715))/((R850 - R685)/(R850 + R685))
CCI	Chlorophyll/carotenoid index	(R531 - R685)/(R531 + R685)

Figure 1. Study site and data collection. Space-borne DESIS and proximal, near-canopy FLoX data were collected during the 2019-2022 growing season at the Smithsonian Environmental Research Center (SERC) NEON site. The lower panel depicts the installation of the FLoX components (box, downwelling and upwelling optics), the NEON tower and the NEON team, including John Schnebelen and Tanner Conrad which were extremely helpful and contributed for the success of the collections.

RESULTS

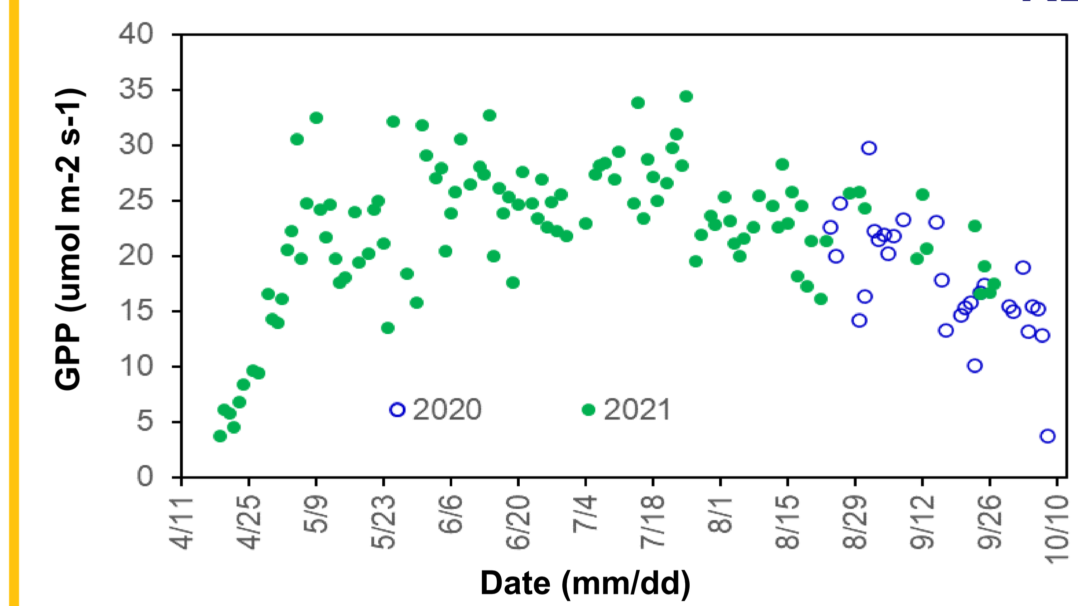

Figure 2. Gross primary productivity (GPP) measured at SERC/NEON.

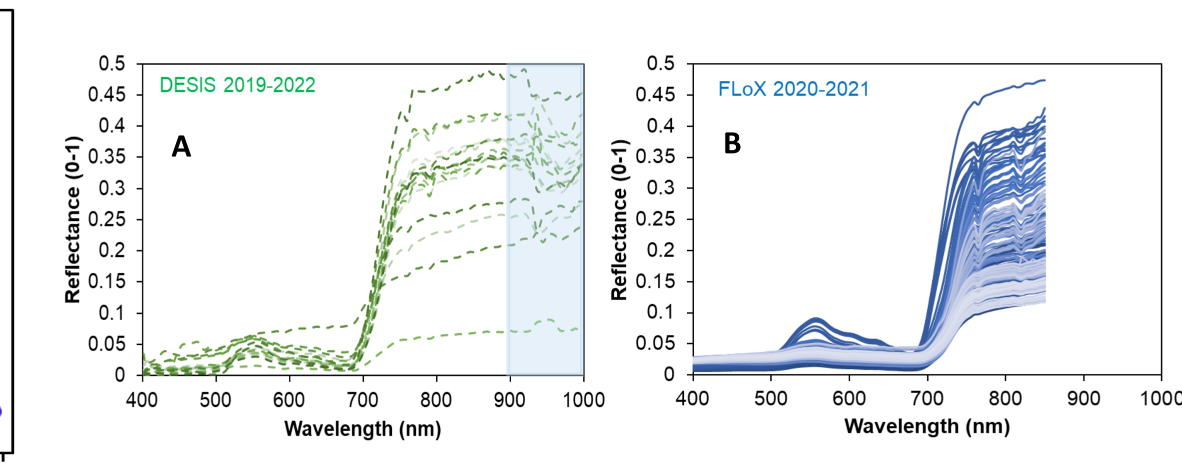

Figure 3. Canopy reflectance measured by DESIS (A) and FLoX (B).

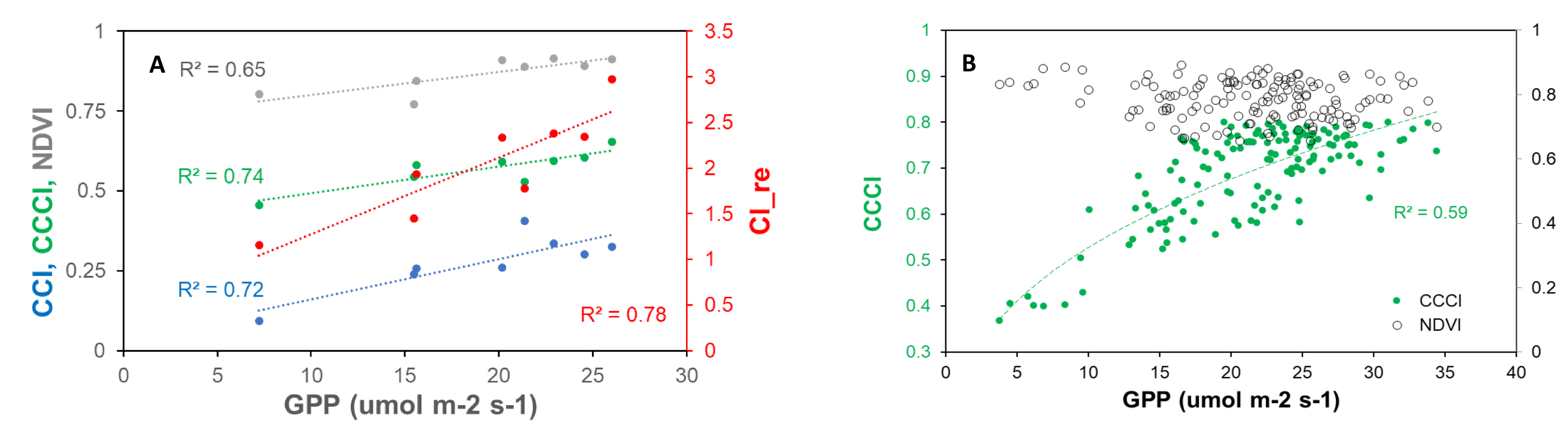

Figure 4. Association between canopy reflectance indices (Tab. 1, A. DESIS, B. FLoX) and GPP

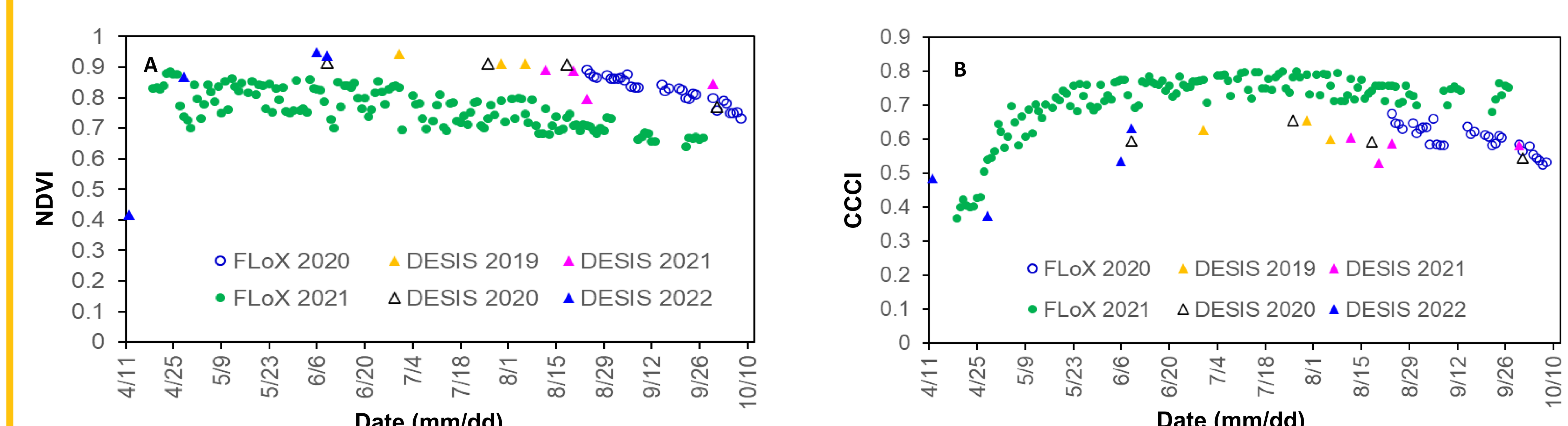

Figure 5. Comparison between DESIS and FLoX of the seasonal distribution of NDVI (A) and CCCI (B) (VI formulas Tab. 1).

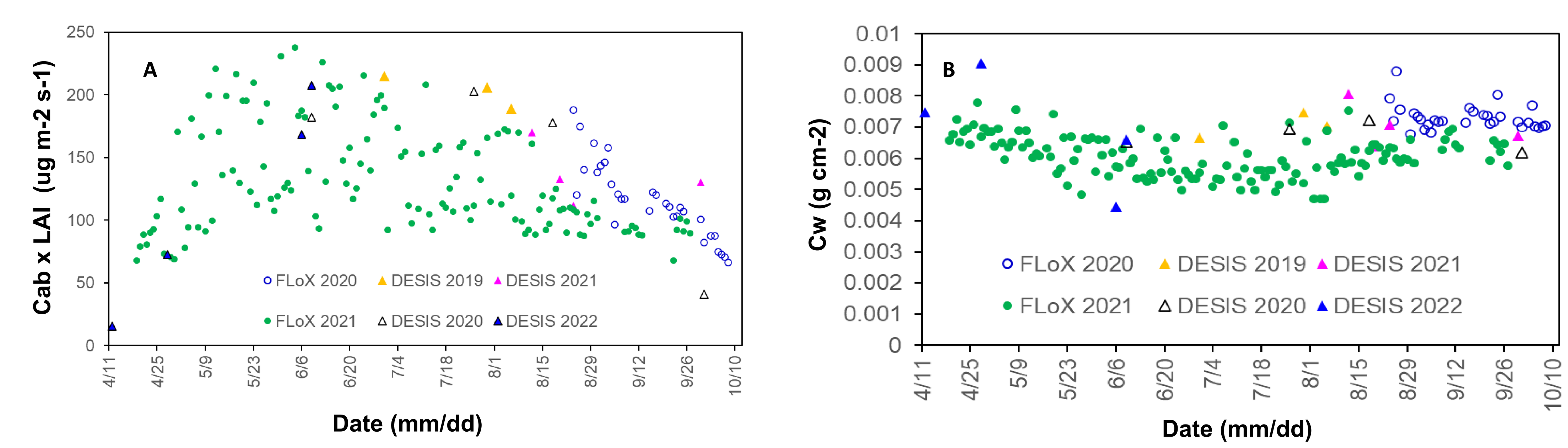

Figure 6. Comparison between DESIS and FLoX of the seasonal distribution of chlorophyll (Cab, A) and water (Cw, B) content derived with SCOPE.

CONCLUSIONS AND FUTURE WORK

The space-borne seasonal and dense proximal FLoX time series corresponded reasonably for the same timeframe and represented the dynamics in canopy traits associated with phenology. Using the biophysical model SCOPE we obtained estimates of canopy chlorophyll, water content, LAI, GPP and others which were more accurate (e.g., lower RMSE) using the proximal FLoX as compared to the space-borne DESIS, which is likely due to the imperfection of the atmospheric correction to surface reflectance of the DESIS data. To further compare the two datasets and assess the drivers of uncertainty for the estimated traits at SERC, additional analysis will be conducted using only the DESIS pixels from the FloX field of view. We will extend the study to include similar analysis for crops, suing available collections for the USDA, OPE3 agricultural research site at Greenbelt, MD. Our preliminary results show the importance of obtaining dense hyperspectral time series for monitoring the seasonal dynamics in vegetation function. The constellation of forthcoming spectroscopy missions, such as SBG, PACE, CHIME, etc. hold great potential to develop multi-sensor time-series that capture vegetation dynamics numerous times per month and season to enable trait comparisons across multiple seasons and years.

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